Control of flux pinning in high temperature superconducting tapes

Scientific Achievement

We have elucidated the role of microstructural defects on the performance of $YBa_2Cu_3O_x$ (YBCO) superconducting tapes in applied magnetic field. Our studies have revealed a subtle change in defect structure that explains how the critical current carried by a tape can vary as a function of composition. The exchange of one defect type for another yields very different behavior in current-carrying capability and exposes a rich interplay between composition and processing that suggests new paths to understand this behavior more fully.

Using scanning and transmission electron microscopy, we found that the dominant defect in baseline-composition YBCO tapes is extended planar defects. These planar defects can promote flux pinning for magnetic fields oriented parallel to the surface of the tape. The high density of these defects in the baseline composition explains the high critical current when the magnetic field is imposed in this direction. If Er is added to the baseline composition, non-superconducting $(Y,Er)_2O_3$ particles become the dominant defect feature at the expense of the extended planar defects. These $(Y,Er)_2O_3$ particles are responsible for enhanced pinning and current density under applied fields oriented perpendicular to the tape surface while the loss of the extended planar defects leads to a decrease in critical current for field aligned parallel to the surface. Thus, the exchange of one type of defect for another explains the significant change in behavior.

Significance

Understanding how defects influence flux pinning is important both for a better understanding of the fundamental aspects of flux pinning and for practical application of superconducting tapes. By learning how these various defects form and interact with magnetic vortices, we hope to manipulate properties more effectively. The decrease in planar defect density with increasing Er addition suggests a change in phase assemblage that must be understood to exploit these possibilities. Our studies will provide this information and help guide stoichiometry and processing for optimal performance.

Performers

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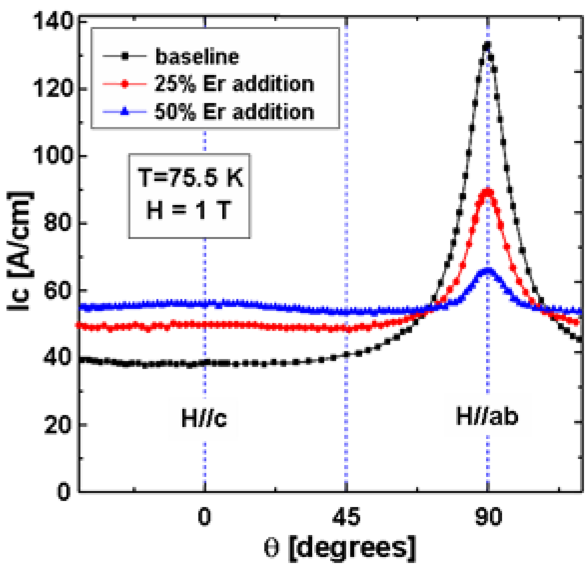
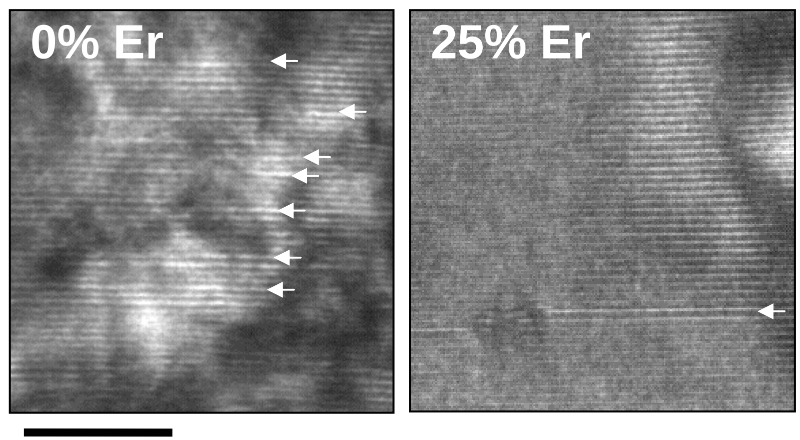
Microstructural defects introduced by composition influence flux pinning behavior in HTS tapes.

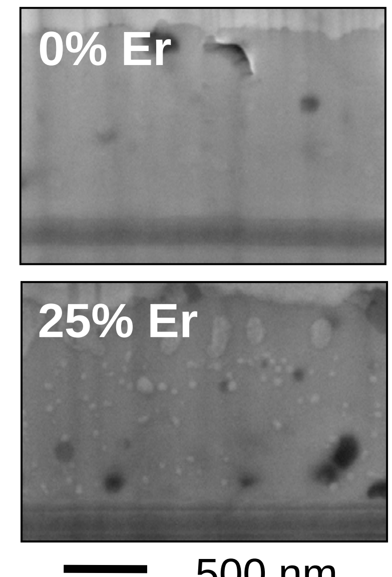


The exchange of extended planar defects for small, equiaxed oxide particles with Er additions leads to changes in performance.



25 nm

Planar defects by TEM



500 nm

Oxide particles by SEM

Our goal is to tailor these properties by manipulation and control of defect formation.

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